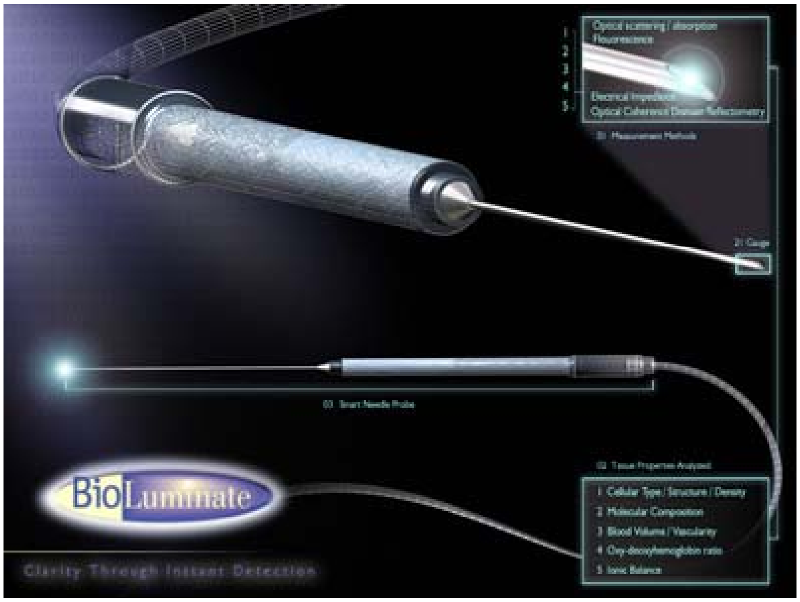
Smart Surgical Probe

Bioluminate, Inc.



Neurosurgeons currently search for tumors manually using a metal biopsy needle that is inserted into the brain. Guided by ultrasound and modern imaging techniques such as MRI/CT scans, they use tactile feedback to localize the tumor. This method, however, can be imprecise as the tumors can easily shift during surgery causing healthy tissue to be mistakenly treated as tumorous tissue. This inaccuracy can increase the risk of a stroke should the needle accidentally sever an artery.

A new technique, which is a combination of hardware and software, has been developed using new technologies. The new technique gives neurosurgeons the ability to find their way through the brain while doing less damage as they operate. This development of a new robotic "smart surgical tool" may also have benefits for breast and prostate cancer diagnosis and surgery.

The primary piece of the hardware is a robotic probe that has on its tip several miniature sensors: an endoscope that transmit images, and instruments that measure tissue density and blood flow. This probe with multimodality sensing capability is inserted into the brain and guided through it by a robotic mechanism which is more precise and accurate than human hands.

The real power is the sophisticated, adaptable "neural network/fuzzy logic" software that provides an instant in-depth analysis of the data gathered by the probe. Surgeons will be able to look at a computer screen in the operating room and see a vast array of useful real-time information about what is going on in the brain, such as if the probe is encountering healthy tissue, blood vessels, or a tumor. The "neural net/fuzzy logic" software is adaptable in that it learns from experience what is normal tissue and what is tumorous tissue based on laboratory biopsy test results.

Benefits The new technique will give surgeons finer control of surgical instruments during delicate brain operations. The probe will enter the brain gently under robotic control and will locate the edges of tumors while preventing damage to critical arteries. The "neural net/fuzzy logic" software will provide real-time tissue identification, thus improving diagnostic accuracy and precision of surgery. Overall, the new technique will increase the safety, accuracy, and efficiency of surgical procedures.

Potential Applications The impact from this work is the potential development of a whole new generation of smart surgical tools to increase the safety, accuracy and efficiency of surgical procedures. Likely markets include smart surgical tools for application specific tissue diagnosis and localization (real-time biopsy), exploratory surgery, colon cancer surgery, prostate surgery cancer and breast cancer surgery.

Current Capabilities The current prototype is the second hardware prototype built. The first prototype (with one motor drive) demonstrated the basic capabilities described above. The second prototype (with two motor drives) provided additional sensor capabilities and was implemented on a personal computer workstation.

A third prototype is currently being developed to provide multimode sensor capabilities in a modular design and to provided enhanced performance capability. The Windows NT software interface is being upgraded to improve user friendly control of the device, presentation of the surgical data, displays of the real-time tissue identification information, and graphical 3-dimensional virtual view of the surgery as it occurs.

Technical Basics The detection of tissue interface (e.g., normal tissue, cancer, tumor) has been limited clinically to tactile feedback, temperature monitoring, and the use of a miniature ultrasound probe for tissue differentiation during surgical operations. In brain surgery, the needle used in the standard stereotactic CT or MRI guided brain biopsy provides no information about the tissue being sampled. The tissue sampled depends entirely upon the accuracy with which the localization provided by the preoperative CT or MRI scan is translated to the intracranial biopsy site. Any movement of the brain or localization device results in an error in biopsy localization.

Moreover, no information about the tissue being traversed by the needle (e.g., a blood vessel) is provided. Hemorrhage due to the biopsy needle tearing a blood vessel within the brain is the most devastating complication of stereotactic CT/MRI guided brain biopsy.

The new technique provides robotic control of the insertion of the surgical probe into the brain, utilizing servo-controlled motors to drive the probe movements precisely and gently. The surgical probe is instrumented with a variety of miniature sensors which can be inserted simultaneously or individually through a cannula, thus providing multimode sensory feedback for obtaining a unique characteristic signature of the tissue being sensed at the tip of the probe.

Near real-time learning neural net/fuzzy logic software is utilized to learn the characteristics of normal and abnormal tissues. Laboratory biopsy test results are used to validate the data used for training the neural net/fuzzy logic software. Once trained, the neural net/fuzzy logic software can be used to identify in real-time abnormal tissues encountered during surgical operations. Once learned, the probe is robotically advanced and stopped immediately when it detects a signature significantly different from what was learned as normal tissue. At this point, tissue identification is performed automatically and the results presented to the surgeon. The surgeon can then treat the abnormal tissue as appropriate and without delay.

Technology Commercialization Status The NASA Ames Research Center has granted an exclusive license to Bioluminate, Inc. for the Smart Surgical Probe. The Smart Surgical Probe is also a patented (U.S. 6109270) technology . The system was originally invented by Dr. Robert Mah and Dr. Russell Andrews.

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For other work by Dr. Robert Mah, please visit the following webpage at: http://ic-www.arc.nasa.gov/ic/projects/Computational-Intelligence.html